

## CLAIMS

What is claimed is:

1           1. A film bulk acoustic resonator formed on a substrate, the film bulk  
2 acoustic resonator comprising:  
3           a layer of piezoelectric material including:  
4               a first surface proximate the substrate;  
5               a second surface distal from the surface of the substrate;  
6           a first conductive layer including a portion in contact with the first  
7 surface of the layer of piezoelectric material, the first conductive layer being  
8 nonplanar ; and  
9           a second conductive layer in contact with the second surface of the layer  
10 of piezoelectric material.

1           2. The film bulk acoustic resonator of claim 1 wherein the first  
2 conductive layer and the second conductive layer are deposited on the first  
3 surface and second surface of the layer of piezoelectric material.  
4

1           3. The film bulk acoustic resonator of claim 1 wherein the layer of  
2 piezoelectric material is a single-crystal film.

1           4. The film bulk acoustic resonator of claim 3 wherein the layer of  
2 piezoelectric material is AlN.

1           5. The film bulk acoustic resonator of claim 3 wherein the layer of  
2 piezoelectric material is ZnO.

1           6. The film bulk acoustic resonator of claim 3 wherein the layer of  
2 piezoelectric material is a C-axis orientated film.

1           7. The film bulk acoustic resonator of claim 1 wherein the layer of  
2 piezoelectric material includes:

3           a C-axis oriented portion; and  
4           a non C-axis oriented portion, wherein at least a portion of the first  
5   conductive layer and a portion of the second conductive layer is proximate the  
6   C-axis oriented portion of the layer of piezoelectric material.

1           8. The film bulk acoustic resonator of claim 1 wherein the first  
2   conductive layer includes:  
3           a first planar portion; and  
4           a second planar portion, the first planar portion and the second planar  
5   portion having surfaces in different planes.

1           9. A method for forming a device in a substrate comprising:  
2           depositing a first portion of a first electrode onto the substrate;  
3           depositing a piezoelectric layer on the substrate and a portion of the first  
4   portion of a first electrode, the piezoelectric film layer having a first surface  
5   proximate the substrate and a second surface remote from the substrate;  
6           placing a second electrode on the second surface of the piezoelectric  
7   layer;  
8           removing a portion of the substrate under the piezoelectric layer and  
9   under the portion of the first electrode; and  
10          depositing a second portion of the first electrode onto the first surface of  
11   the piezoelectric film layer and onto the first portion of the first electrode.

1           10. The method of claim 9 wherein the piezoelectric layer is a single  
2   crystal piezoelectric film.

1           11. The method of claim 9 further comprising removing a portion of the  
2   first surface of the piezoelectric layer.

1           12. The method of claim 11 further comprising removing a portion of  
2   the first portion of the first electrode.

1           13. The method of claim 9 further comprising placing the second portion  
2 of the first electrode in electrical contact with the first portion of the first  
3 electrode.

1           14. A method for forming a device in a substrate comprising:  
2           placing a first portion of a first electrode onto the substrate;  
3           placing a piezoelectric layer on the substrate and on a portion of the first  
4 portion of the first electrode, the piezoelectric layer having a first surface  
5 proximate the substrate and a second surface remote from the substrate;  
6           placing a second electrode on the second surface of the piezoelectric  
7 layer;  
8           removing a portion of the substrate under the piezoelectric layer and  
9 under the portion of the first electrode;  
10          placing a second portion of the first electrode onto the first surface of the  
11 piezoelectric film layer and onto the first portion of the first electrode.

1           15. The method of claim 14 further comprising the step of placing a seed  
2 layer onto the substrate.

1           16. The method of claim 15 wherein the seed layer is non-conductive.

1           17. The method of claim 14 further comprising removing a portion of  
2 the first surface of the piezoelectric layer.

1           18. The method of claim 15 further comprising removing a portion of  
2 the seed layer under the piezoelectric layer and under the portion of the first  
3 electrode.

1           19. The method of claim 15 wherein the seed layer is a single crystal  
2 seed layer.

1           20. The method of claim 15 wherein the seed layer is capable of  
2 growing a single crystal piezoelectric film.

1           21. The method of claim 15 wherein the seed layer is conductive.

1           22. The method of claim 21 further comprising removing a portion of  
2 the first surface of the piezoelectric layer.

1           23. A method for forming a device in a substrate comprising:  
2 depositing a dielectric layer onto the substrate;  
3 depositing a seed layer onto the dielectric layer;  
4 depositing a first portion of a first electrode onto the dielectric layer;  
5 depositing a piezoelectric layer on the dielectric layer and on a portion  
6 of the first portion of the first electrode, the piezoelectric layer having a first  
7 surface proximate the substrate and a second surface remote from the substrate;  
8 placing a second electrode on the second surface of the piezoelectric  
9 layer;  
10 removing a portion of the substrate under the piezoelectric layer and  
11 under the portion of the first electrode;  
12 removing a portion of the dielectric layer under the piezoelectric layer  
13 and under the portion of the first electrode;  
14 removing a portion of the seed layer under the piezoelectric layer and  
15 under the portion of the first electrode;  
16 depositing a second portion of the first electrode onto the first surface of  
17 the piezoelectric film layer and onto the first portion of the first electrode.

1           24. The method of claim 23 wherein the seed layer is non-conductive.

1           25. The method of claim 24 further comprising removing a portion of  
2 the first surface of the piezoelectric layer.

1           26. The method of claim 23 wherein the seed layer is  
2 conductive.

1           27. The method of claim 26 further comprising removing a portion of  
2 the first surface of the piezoelectric layer.

1           28. The film bulk acoustic resonator of claim 1 the substrate includes an  
2 opening therein, the film bulk acoustic resonator positioned over the opening in  
3 the substrate.

1           29. A film bulk acoustic resonator device formed on a substrate having  
2 an opening therein, the film bulk acoustic resonator comprising:  
3           a seed layer exposed about the periphery of the opening; and  
4           a layer of piezoelectric material spanning the remaining portion of the  
5 opening.

1           30. The film bulk acoustic resonator device of claim 29 wherein the  
2 opening has a larger area near the layer of the piezoelectric material and a  
3 smaller area remote from the piezoelectric material.

1           31. The film bulk acoustic resonator device of claim 29 wherein the  
2 substrate further includes a major surface, the opening further including at least  
3 one sidewall, the angle between the at least one sidewall and the major surface  
4 of the substrate at an angle other than perpendicular.

1           32. The film bulk acoustic resonator device of claim 29 wherein the seed  
2 layer is in a first plane and the layer of piezoelectric material is in a second  
3 plane.

1           33. The film bulk acoustic resonator device of claim 29 further including  
2 a conductive layer.

1           34. The film bulk acoustic resonator device of claim 33 wherein the seed  
2 layer is in a first plane, the layer of piezoelectric material is in a second plane,  
3 and at least a portion of the conductive layer is in a first plane.

1           35. The film bulk acoustic resonator device of claim 29 further  
2 comprising:  
3           a first conductive layer; and

4 a second conductive layer, the first conductive layer deposited on a first  
5 surface of the piezoelectric material, and the second conductive layer deposited  
6 on a second surface of the layer of piezoelectric material.

1 36. The film bulk acoustic resonator device of claim 35 further  
2 comprising:  
3 a first electrode; and  
4 a second electrode, wherein the first conductive layer is a portion of the  
5 first electrode, and the second conductive layer is a portion of the second  
6 electrode.

1 37. The film bulk acoustic resonator device of claim 36 wherein at least  
2 one of the first electrode, and the second electrode has portions which are in  
3 different planes.

1 38. The film bulk acoustic resonator device of claim 36 wherein both the  
2 first electrode, and the second electrode have portions which are in different  
3 planes.

1 39. The film bulk acoustic resonator of claim 29 wherein the layer of  
2 piezoelectric material is a single-crystal film.

1 40. The film bulk acoustic resonator of claim 29 wherein the layer of  
2 piezoelectric material is AlN.

1 41. The film bulk acoustic resonator of claim 29 wherein the layer of  
2 piezoelectric material is ZnO.

1 42. The film bulk acoustic resonator of claim 29 wherein the layer of  
2 piezoelectric material is a C-axis orientated film.

1 43. The film bulk acoustic resonator of claim 29 wherein the layer of  
2 piezoelectric material includes:  
3 a C-axis oriented portion; and

4 a non C-axis oriented portion, wherein at least a portion of the first  
5 conductive layer and a portion of the second conductive layer is proximate the  
6 C-axis oriented portion of the layer of piezoelectric material.

1 44. The film bulk acoustic resonator of claim 29 wherein the seed layer  
2 is nonconductive.

1 45. A film bulk acoustic resonator device formed on a substrate having  
2 an opening therein, the film bulk acoustic resonator comprising:  
3 a seed layer of non conductive material; and  
4 a layer of piezoelectric material contacting the seed layer of non-  
5 conductive material.

1 46. The film bulk acoustic resonator of claim 45 wherein the seed layer  
2 also has an opening therein that corresponds to the opening in the substrate, the  
3 opening in the seed layer including a layer of conductive material.

1 47. The film bulk acoustic resonator of claim 46 wherein the conductive  
2 material within the opening in the seed layer is a portion of a first electrode  
3 associated with a first surface of the layer of piezoelectric material.

1 48. The film bulk acoustic resonator of claim 47 further comprising a  
2 second electrode associated with a second surface of the layer of piezoelectric  
3 material.

1 49. The film bulk acoustic resonator of claim 48 further comprising a  
2 source of RF voltage attached between the first electrode and the second  
3 electrode.